ODEL 101 VAN METER
BAC-116047

DYNAMICS STAFF

6J5 - 150 170 V
6SF5 - 200

Electronic Tools for Industry

John Fluke Manufacturing Co., Inc.
1111 W. Nickerson St., Seattle 99, Wash.

DYNAMICS STAFF

JOHN FLUKE MFG. CO., INC
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SEATTLE 99, WASH.

MODEL 101 VAW METER

Operating Instructions

FOR THE MEASUREMENT OF VOLTS, AMPERES AND WATTS OVER WIDE RANGES AND AT FREQUENCIES OF 20 TO 200,000 CPS

The Model 101 VAW Meter is a highly useful instrument for the measurement of a-c Volts, Amperes and Watts from low audio through supersonic frequencies. This unique instrument, with its high input impedance, its small size, its accuracy and simplicity and its wide range of measurement of Volts, Amperes and Watts over this extended frequency range, provides an indisputably outstanding measuring device for a-c measurements in the electrical and electronic fields.

MODEL 101 VAW METER

Electrical Specifications

Voltage Ranges: Eight: .1, .3, 1, 3, 10, 30, 100, 300 RMS VOLTS

Ampere Ranges: Ten: .001, .003, .01, .03, .1, .3, 1, 3, 10, 30 RMS AMPERES.

Watt Ranges:

	AMPERES									
	.001	.003	.01	.03	.1	.3	1	3	10	30
.1	.0001	.0003	.001	.003	.01	.03	.1	.3	1	3
.3	.0003	.0009	.003	.009	.03	.09	.3	.9	3	9
1	.001	.003	.01	.03	.1	.3	1	3	10	30
3	.003	.009	.03	.09	.3	.9	3	9	30	90
10	.01	.03	.1	.3	1	3	10	30	100	300
30	.03	.09	.3	.9	3	9	30	90	300	900
100	.1	.3	1	3	10	30	100	300	1000	3000
300	.3	.9	3	9	30	90	300	900	3000	9000

Frequency Range: 20 to 200,000 cycles per second.

Overall Accuracy: Within plus or minus 3% of full scale value for any reading from 20 to 200,000 cps.

Volt and Ampere Readings: In terms of the average value of the rectified full sine wave.

Watt Readings: In terms of the product of rms volts, rms amperes and the cosine of their phase displacement angle (VA cos Ø). If harmonics are present, readings will be sum of powers due to fundamental and harmonics.

Meter Calibration: Selectively reads rms volts, rms amperes or watts.

Scales: All scales are linear. Scale arcs graduated 0-10, 0-9, 0-3.

Input Shunt Impedances: Input capacity approximately 25 mmfd.
Input resistance 1 Megohm on all voltage ranges.

Drop at Shunts for full Scale Amperes: Five millivolts.

Overload Capacity: About 3 times on "A" and "W" ranges and 15 times on "V" range. Overload limited by voltage rating of input capacitors and current carrying capacity of terminals and shunts.

Regulated Power Supply: Line voltage variations from 105 to 130 volts at 60 cps cause less than 1% variation in readings.

Power Requirements: 117 volts, 50-60 cps, 1.05 amperes, 105 watts. Power transformer tapped at 105 volts.

Electrical Specifications

Voltage Ranges: Eight: .1, .3, 1, 3, 10, 30, 100, 300 MIC VOLTS

Ampere Ranges: Ten: .001, .003, .01, .03, .1, .3, 1, 3, 10, 30 MIC AMPERES.

Watt Ranges:

	.001	.003	.01	.03	.1	.3	1	3	10	30
.1	.0001	.0003	.001	.003	.01	.03	.1	.3	1	3
.3	.0003	.0009	.003	.009	.03	.09	.3	.9	3	9
1	.001	.003	.01	.03	.1	.3	1	3	10	30
3	.003	.009	.03	.09	.3	.9	3	9	30	90
10	.01	.03	.1	.3	1	3	10	30	100	300
30	.03	.09	.3	.9	3	9	30	90	300	900
100	.1	.3	1	3	10	30	100	300	1000	3000
300	.3	1	3	9	30	90	300	900	3000	9000

Frequency Range: 30 to 300,000 cycles per second.

Overall Accuracy: Reading from 20 to 300,000 cps.
Within plus or minus 5% of full scale value for any

Volt and Ampere Readings: In terms of the average value of the rectified full sine wave.

Watt Readings: In terms of the product of rms volts, rms amperes and the cosine of their phase displacement angle (W = EI cos θ). If harmonics are present, readings will be in terms of power due to fundamental and harmonics.

Selectivity: Selectively reads rms volts, rms amperes or watts.

Controls:

Scales: All scales are linear. Scale arcs graduated 0-10, 0-3, 0-3.

Input Shunt Impedance: Input capacity approximately 45 mmfd.
Input resistance 1 megohm on all voltage ranges.

Drop at Diode for full scale amperes: Five milivolts.

Overload Capacity: Meter & fuses on "A" and "V" ranges and 15 times on "W" range. Overload limited by voltage rating of input capacitors and current carrying capacity of rectifier in any shunt.

Regulated Power Supply: Line voltage variations from 105 to 130 volts at 60 cps causes less than 1% variation in readings.

Power Requirements: 117 volts, 50-60 cps, 1.05 amperes, 105 watts. Power transformer tapped at 105 volts.

Fuse Rating: Three Amperes.

Mechanical Specifications

Weight: 27 pounds.

Dimensions: 10" high, 12" deep, 16" wide (less handles and knobs)

Finish: Baked gray wrinkle enamel, smooth gray on front panel.

OPERATING INSTRUCTIONS

GENERAL

Before initially operating the Model 101 VAW Meter make certain that the meter pointer is set on zero and that the instrument has not been damaged in transit. Connect the power cord to an appropriate power source and turn the power switch to the "on" position. Allow four to five minutes for the instrument to heat. Set the selector switch to "W and rotate the "W Zero" knob (small knob in center bottom of panel) until the meter pointer is on zero. This zero adjuster is effective for the wattmeter ranges only. Once it has been set very little future adjustment will be required. Particularly is this true if adjustment is made after the instrument is well warmed (10 to 15 minutes).

The selector switch (VAW) should be set to "V" during changing of the shunts. During switching of the voltage range switch or changing shunts a transient deflection of the meter pointer will take place. This condition is normal and does not indicate malfunctioning of the instrument. Switching the voltage range switch or changing shunts with the "VAW" switch in other than the "V" position may cause the transient deflections of the meter pointer to be more violent than with the "VAW" switch in the "V" position.

It is desirable, notwithstanding the overload capacity inherent in this instrument, to set the voltage range switch to one of the higher ranges prior to connection to a source of unknown voltage. A shunt for the current range should always be selected so that a shunt of suf-

ficiently high range is used. In general, the shunt rating should never be exceeded by more than three times.

If the ground terminal (terminal marked "G") is connected to a potential above ground, adequate precautions should be taken to insulate the instrument case from surrounding objects and personnel since the "G" terminal is connected internally to the case.

In connecting the instrument in a circuit whose voltage, current and power are to be measured the terminal "G" should be connected to the grounded side of the power source, one of the terminals marked "H" to the high side of the power source and the other terminal "H" and the terminal "L" to the load. The two terminals "H" are bussed together inside the instrument. These connections are shown in Fig. 1.

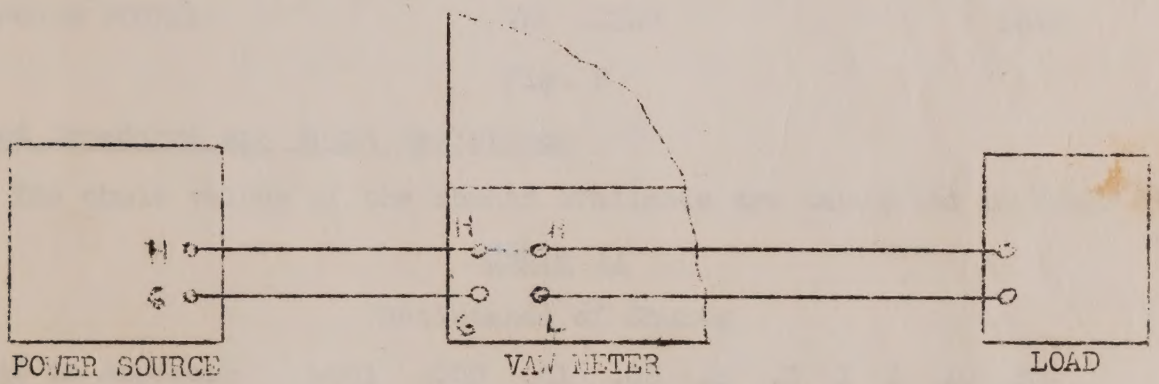
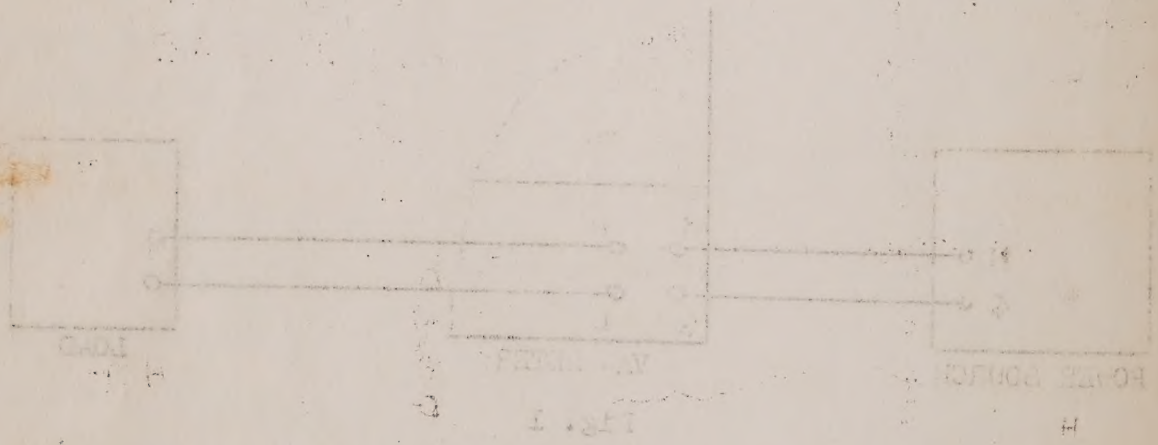


Fig. 1

Obviously the load should not be grounded, otherwise the shunt will be short circuited by the dual grounding of the load and generator. If the generator is ungrounded and the load grounded, then the connections to the "L" and "G" terminals should be interchanged. Though no dual grounding exists, capacity to ground of the load should be kept low to prevent its reactance at the circuit frequency from appreciably shunting the ammeter shunt element. Since the resistance of the shunts are small, appreciable capacity to ground must be present to cause any error.



Where both the load and generator must be grounded it is necessary to isolate the two grounds electrically. This may be accomplished thru the use of a transformer as shown in Fig. 2. Here again, however, the transformer winding must not have sufficient capacity to ground to prevent its reactance at the circuit frequency from appreciably shunting the ammeter shunt element.

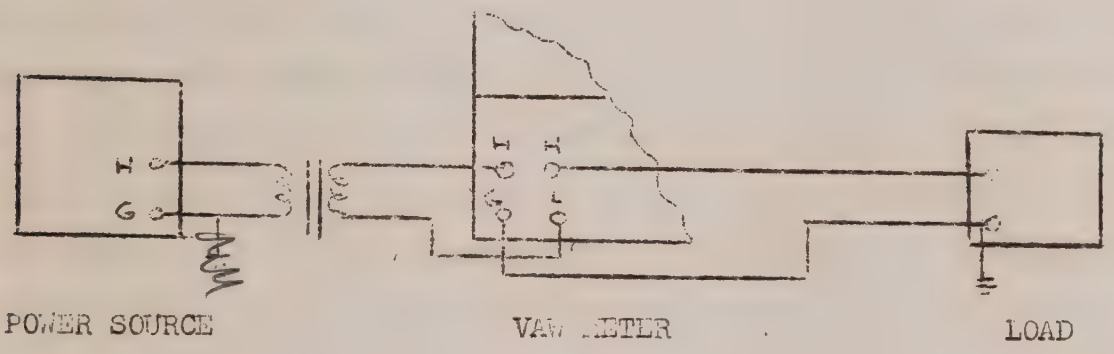


Fig. 2

Input Impedance and Shunt Resistance

The ohmic values of the shunts available are tabulated in Table II.

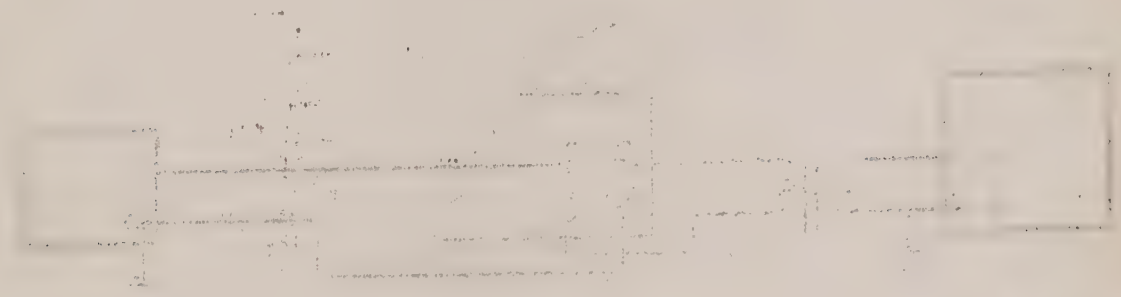
Table II

Resistance of Shunts

Range in Amperes:	.001	.003	.01	.03	.1	.3	1	3	10	30
Resistance of Shunt in ohms:	5	1.667	.5	.1667	.05	.01667	.005	.001667	.0005	.0001667

The input impedance imposed across the circuit by the VAW METER is constant at one megohm for all voltage ranges. In parallel with this resistance there is a capacitance of approximately 25 uufd.

It should be noted that while the shunt drop is 5 millivolts this drop is that occuring at rated shunt current at the ends of the shunt resistor where the current proportional voltage is derived. Between the terminals "G" and "L" the drop may exceed this value at frequencies above approximately 20 kc for the higher current shunts. This excess voltage drop is due primarily to the reactance of the short busses in-



side the instrument reaching a maximum of about 35 millivolts between the "G" and "L" binding posts for the 30 ampere shunt at its rated current at 200 kc.

Calibration

The volt and ampere ranges of the Model 101 VAW Meter are calibrated to read the root-mean-square (rms) value of a sine wave. The voltmeter and ammeter, however, are responsive to the average value of the rectified full wave. Thus if the voltage or current waves are pure sine waves there are no errors due to waveform in the volt or ampere readings. If harmonics are present the resulting error is dependent both on the number, magnitude and phase relationships of the harmonics. While it may be difficult or impossible to determine all these factors, it is helpful to know the maximum error which can be present. This information is given for several cases in Table III.

Table III

% Harmonic	Actual RMS Value	Model 101 "V" or "A" Reading	Peak Meter Reading
0	100	100	100
10% 2nd	100.5	100	90-110
20% 2nd	102	100-102	80-120
50% 2nd	112	100-110	75-150
10% 3rd	100.5	96-104	90-110
20% 3rd	102	94-108	82-120
50% 3rd	112	90-116	108-150

The wattmeter readings are a product of volts, amperes and the cosine of the angle of their relative phase displacement, or W = VA cos ϕ. There is inherently no harmonic error in the wattmeter reading. Consequently, the wattmeter will read the sum of the quantities $V_nA_n \cos \phi_n$ where the subscripts "n" denote corresponding fundamental and harmonic quantities. Therefore, for voltage and current inputs to the

Model 101 VAW Meter which contain harmonics and where the load is resistive, multiplication of the "V" and "A" readings will not necessarily give a product equal to the "W" reading.

At low frequencies, in the 20 cycle region, the meter pointer will tend to oscillate slightly when on the "W" range. This condition is normal and does not indicate malfunctioning.

Circuit Description

The instrument is comprised, in general, of two amplifier channels, networks for deriving signals proportional to circuit voltage and current, a multiplying element, a panel meter and a power supply for supplying direct current power.

In more detail, the signal proportional to circuit voltage is modified suitably in amplitude and applied to a feedback amplifier composed of tubes V1 and V2 shown on the wiring diagram in the back of this instruction book. The signal proportional to circuit current is derived from a shunt and amplified by tubes V12 and V11 operated as a feedback amplifier. The output of V11 is made available as amplified and also inverted in phase by tube V9 for further use in the instrument.

In the measurement of circuit volts by the VAW Meter the signal appearing at the output of V2 is applied to a feedback amplifier comprised of tubes V3 and V4. The output of this amplifier is rectified by RE 1 and RE 2, two germanium diodes arranged for full wave rectification, and applied to the dc panel meter M.

For measuring circuit amperes with the VAW Meter the output of the phase inverter is applied to a feedback amplifier consisting of V8 and V7. The output of this amplifier is rectified by RE 1 and RE 2 and applied to the panel meter in the same manner as for measuring volts.

Selection of the circuitry for accomplishing the previously de-

scribed readings of volts and amperes is accomplished by the several sections of switch S1 which is the "VA./" switch. This same switch is also used to establish the appropriate circuits for measuring watts. In the measurement of watts the outputs of tubes V2, V9 and V11 are applied to two tubes, V10 and V20, which produce two outputs one of which is applied to amplifier V3 and V4 and the other applied to amplifier V8 and V7. The outputs of these two amplifiers are respectively applied to power amplifiers V5 and V6 whose output, in turn, is applied to the wattmeter element "S". The output of "S" is applied to the panel meter to accomplish a reading of circuit watts.

All amplifiers and appropriate circuit components are designed, constructed and adjusted to reproduce the input signals with substantially flat response in both amplitude and phase throughout the rated frequency range. It will be observed from the wiring diagram that compensating capacity is liberally used to obtain good amplitude and phase response. It is essential in servicing the instrument not to rearrange or disturb portions of the circuit containing these trimming capacities since such will result in creating reading errors at the higher frequencies. Also, the wattmeter element "S", which is solder-sealed and liquid filled, should not be disturbed. Tampering with this unit may result in errors in the watts readings. There are no thermal elements, moving parts, vacuum tubes, or rectifiers in the wattmeter element. Its construction is such as to require no replacement under even severe operating conditions. It is entirely unsusceptible to overload and will normally retain its excellent accuracy indefinitely if not unsealed. The wattmeter element will withstand mechanical shocks of such force as to severely damage the remainder of the instrument. No responsibility for the proper functioning of the instrument is assumed after any attempt to unseal the wattmeter element. Should trouble develop which is thought to be traceable to the

wattmeter element, it is highly recommended that the instrument be returned to the factory for check. This service, recalibration of the instrument or repair and recalibration will be performed at the factory at a very nominal charge covering only direct labor and replacement components involved.

It will be noted that all plate power requirements of the amplifiers are supplied through a regulated power supply. This power supply possesses excellent regulation and the very low effective impedance (internal) of about .01 ohm. The power transformer is arranged to supply the filaments of tubes V1 thru V12 from one secondary, and the rectifier tube filament from another secondary. Two more low voltage secondaries supply the filaments of the regulator amplifier V14 and the series tube V16. A high voltage secondary is also provided whose output is rectified by V17, filtered by a pi LC network, and applied to the regulator. The regulator is comprised of four tubes V13, V14, V15 and V16. V15 establishes a reference voltage which is compared to the output of the regulator dropped to a more usable level by a second regulator tube V13. The voltage difference thus obtained is applied to a two stage, direct coupled amplifier tube V14. Owing to the high gain of this amplifier and because nearly the entire amplitude of any attempted fluctuation of the regulator output voltage is applied directly to the input of V14, a very good degree of regulation, with the resultant low effective internal impedance, is obtained by the high degree of control of V14 on the series regulator tube V16.

The shunts available with the V.. Meter are adjusted to have a constant resistance drop thruout their rated frequency range. The adjustment is dependent on the physical arrangement of the wiring inside the shunt case; consequently, it is important that this wiring not be disturbed if the introduction of shunt errors at the upper frequencies

is to be avoided.

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Regulation of filament currents to all amplifier tubes (V1 - V12) is effected through the use of ballast tubes V18 and V19 which maintain this current substantially constant for line voltage variations in excess of 105 to 130 volts. This regulation practically eliminates variation in amplifier gain due to fluctuating heater temperatures. This feature also simplifies requirements of replacement tubes since they need not be selected as critically for constant emission-temperature characteristics as would otherwise be necessary were heater current regulation not employed.

In servicing the instrument care should be taken that the adjustment of the trimmer capacitors and resistors are not disturbed. It is not satisfactory to judge the proper adjustment of these capacitors and resistors from measurement of voltage amplitudes alone. Phase measurements must be employed in order to obtain accurate wattmeter readings when the trimmers in the circuit are adjusted.

APPLICATIONS

The Model 101 VAC Meter has been designed as a general purpose instrument capable of a wide range of measurements. Its high input impedance of one megohm and its low shunt drop will cause substantially no disturbance to most circuits to which it may be connected.

Fig. 1 shows the usual method of connecting the VAC Meter where only the generator is grounded, and where the load is ungrounded. Where the generator is ungrounded and the load grounded the "G" and "L" connections shown in Fig. 1 should be reversed. When both load and generator are grounded it is necessary that advantage be taken of any transformer in the circuit, or that an auxiliary transformer be used, in the manner shown in Fig. 2. Obviously if an auxiliary transformer is used it must be capable of operating at the required voltage

and power level, and over the frequency range at which measurements are to be made. At the higher frequencies, care must be taken that the capacity to ground of the transformer secondary is low enough to prevent appreciable shunting of the instrument shunt.

Aside from numerous special applications, the VAW Meter fills two general, broad purposes. The first is the measurement of voltage, current and power output of a power source. This power source may be a generator, oscillator or amplifier. Whatever the load supplied by the ac power source, the VAW Meter provides a convenient, accurate means of measuring the output of such source into its normal load. Thus it is possible to determine directly both volt-ampere and watt output of a power source into its normal load over a wide frequency range and over wide ranges in level of voltage and power. This feature is of particular value in measuring the output of amplifiers working into the loads for which they were designed rather than resorting to a known dummy resistive load heretofore available as the only general means of measuring amplifier output. Because of the negligible circuit loading imposed by the VAW Meter, it will be found that power outputs of relatively high impedance sources can be measured with accuracy. The frequency response of the instrument is such as to cover the entire audio range as well as the supersonic frequencies.

The second purpose filled by the VAW Meter is the measurement of the characteristics of nearly all types of networks over far greater ranges of level than that generally possible with bridge methods. Since the instrument measures volts, amperes and watts into a load, it is a simple matter, utilizing these measurements, to calculate the vector impedance of the load. In setting up to make these measurements a suitable source of power is required to supply the loads. It is apparent that the power source should cover the frequency range required,

that it should have adequate power output and that it should be free from distortion in order that waveform errors not be introduced into the volt, and ampere readings on the VAW Meter. In general, the power source for this type of measurement will be either a rotating type generator or, more usually, an oscillator. Most oscillators commercially available will deliver several watts output at about ten to forty volts. Excellent oscillators for this purpose are manufactured by the Hewlett-Packard Co., of Palo Alto, Cal. Where power output, in excess of that available from an oscillator, is required it will be necessary to use a suitable amplifier.

From the voltage current and power readings obtained from the VAW Meter, the impedance characteristics of the load being measured may be determined in the following manner. Let the symbols V, A and W represent the readings of volts, amperes and watts obtained from the VAW Meter. Also, let ϕ be the phase angle in degrees measuring the angular displacement between V and A.

Then the power delivered to the load is W and the volt-amperes delivered to the load are (V) (A).

The phase angle is obtained from:

$$\cos \phi = \frac{W}{VA} \tag{1}$$

$$\text{or } \phi = \cos^{-1} \frac{W}{VA} \tag{2}$$

The scalar value of load impedance is, in ohms:

$$|Z| = \frac{V}{A} \tag{3}$$

The load resistance is:

$$R = |Z| \cos \phi \tag{4}$$

The load reactance is:

$$X = |Z| \sin \phi \tag{5}$$

Equations (4) and (5) may be combined to read:

$$Z = R \pm jX = |Z| (\cos \phi \pm j \sin \phi) \tag{6}$$

The sign to be used in equation (6) may be determined from a knowledge of the load characteristics as to whether it is predominantly inductively reactive or capacitively reactive. For the former, the plus sign is used and equation (6) becomes

$$Z = R + jX = |Z| (\cos \phi + j \sin \phi) \qquad (7)$$

If capacitive reactance predominates, equation (6) becomes

$$Z = R - jX = |Z| (\cos \phi - j \sin \phi) \qquad (8)$$

The reactive sign may also be determined by introducing additional reactance across the load. If additional inductance makes the reading of W more nearly equal to the product of (V) (A), then the load is predominantly capacitive in its reactance component. If additional capacitance across the load makes the reading of W more nearly equal to the product of (V) (A), then the load is predominantly inductive in its reactive component. Care must be exercised in the introduction of additional inductance to prevent the drawing of false conclusions through the use of an inductance with excessive losses. Usually it is more satisfactory to use an additional capacity since capacitors with essentially zero loss are generally available in a wide range of values

The Model 101 VA/ Meter will be found to be useful in a number of circuit arrangements for the measurement of power and volt-ampere outputs as well as in the measurement of load characteristics and load or transmission losses. A few of the uses of the instrument, in this respect, are listed below.

1. Measurement of generator, amplifier or oscillator outputs into any desired load over the range of 20 cps to 200 kc.
2. Measurement of inputs and outputs of transmission lines and networks and, consequently, their power loss.
3. Measurement of exciting requirements and losses in transformers, the measurement of power losses in loaded transformers and the

measurement of quantities from which the impedance characteristics of transformers may be calculated.

4. Measurement of power input to loads such as loudspeakers working from the amplifiers with which they are to be used, or for measuring loudspeaker characteristics as a function of radiated energy over various ranges of frequency and output level.
5. Measurement of inductor characteristics at various frequencies with, or without, direct current flowing in the inductor windings.

MAINTENANCE

The components used in the Model 101 VAT Meter have been selected with the view of providing long, trouble-free operation. High quality components have been employed to achieve this end. Parts are well secured in place and located for the maximum ease of inspection consistent with the need for effecting adequate shielding of low level circuits and for minimizing stray circuit capacities. Replacement of tubes at infrequent intervals will probably constitute the major service item to the instrument. Even here, however, the tubes should give long life in view of their conservative use in the design circuit. When tubes are replaced, insignificant changes in calibration should result when the tubes are of normal tolerance owing to the feedback used on all amplifiers. Substandard tubes may affect the calibration somewhat. Also, some tubes may draw excessive grid current or they may have appreciable heater-cathode leakage. The latter evidences itself in a permanent deflection fo the meter pointer on either the A or V ranges when the input terminals are shorted together. Any tube producing a permanent deflection should not be used. Low leakage is, of course, more important on the low level stages where the signals derived from such leakage are amplified by successive stages. Conse-

quently, the leakage requirements for V1, V2, V12, V11 and V10 are the most severe. Of these, V12 is the most critical. This information is given as a precautionary guide in tube replacement and does not indicate that the tube requirements are excessively severe. Usually, no trouble will be experienced in satisfactorily replacing tubes.

Since all amplifiers are operated from the same power supply through a common regulator, it is necessary that the regulator function properly to maintain stability of the instrument readings. Failure of the regulator usually evidences itself either in the inability of the instrument to read, or in transient meter deflection (motor-boating). The former condition is due to a burned out rectifier, V17, or a defective regulator tube, V16, preventing the application of direct voltage to the amplifiers. Under normal conditions the regulator output is about 245 Vdc.

Motor-boating is usually caused by defective regulator tubes (V13 or V15) or by a defective amplifier tube V14.

Also, failure of the instrument to read may be caused by a burned out fuse. This condition is readily indicated by the absence of meter illumination. The fuse is located in a fuse holder, conveniently located on the lower right-hand corner of the front panel. A three ampere fuse should always be used as a replacement if proper protection of the instrument is to be maintained. If a fuse burns out it is always advisable to determine the reason for fuse rupture rather than to simply replace the tube without further investigation.

Calibration of the instrument may be checked in the following manner. First check the calibration of the V range, at a convenient range switch setting, against a known voltage measured by an accurate meter, by a calibrated oscilloscope or by the drop across a standard resistor, the current thru which is measured by an accurate ammeter or thermo

ammeter.

The current range, A, may be checked against an accurate ammeter or thermo ammeter.

The W readings can be then checked utilizing a purely resistive load utilizing an ammeter. The W reading should equal I^2R. Or the W reading should be the equivalent of (V) (A) for a resistive load excited from a sinusoidal voltage source. The ability of the wattmeter to read zero power factor may be checked by utilizing a high quality capacitor, of suitable capacity at the frequency used, as a load.

It is emphasized that instrument wiring associated with trimmer capacitors, and the trimmer capacitors themselves, be left undisturbed in order that the accuracy of the instrument be unimpaired at the higher frequencies. Adjustment of the trimmer capacitors has no affect on calibration below a frequency of approximately 20 kc, consequently, their adjustment will be of no value in any attempt at correcting any error thought to exist at the lower frequencies.

Two 6.3 volt minature bayonet base lamps for illuminating the meter scale, and which also serve as pilot lights, are accessible from the rear of the front panel. The sockets for these lights are friction held in place by spring pressure in transparent plastic cups in the meter case. Removal of the sockets for lamp replacements may be effected by gently pulling the sockets from the plastic cups.

The John Fluke Engineering Company will recalibrate any Model 101 VAW Meter at cost,on a quick service basis, which is returned prepaid to the factory. The same service is offered on any repairs or replacements that may be required. Normally, the equipment required for complete recalibration of the instrument is not available to most users because of the specialized nature of such apparatus. Consequently, it will be found both economical and expedient to return the

instrument to the factory for calibration or repair. Particularly is this true when it is considered that accurate calibration is dependent on more accurate calibration equipment and upon calibration technique.

Much effort has been exerted to build long life into the Model 101 VAW Meter by using quality components, conservative design and rugged construction to provide you with an instrument which is reliable, easily read, convenient to use and capable of providing many years of satisfactory service. It is believed that these objectives have been achieved. Reasonable care in operation and handling the instrument will assist materially in prolonging its service to you.

JOHN FLUKE ENGINEERING COMPANY

SPRINGDALE, CONNECTICUT

CIRCUIT COMPONENTS MODEL 101 VAW METER DWG 101-150A 9-10-48

RESISTORS (values in ohms)

R1	900K	½ watt	½% tol.	Continental Carbon, Type X½
R2	90K	½ watt	½% tol.	do do
R3	9K	½ watt	½% tol.	do Type UX½
R4	1K	½ watt	½% tol.	do do
R5	#30	½ watt		
R6	200	½ watt	½% tol.	Continental Carbon, Type UX½
R7	60	WW pot.	5% tol.	Int. Res. Co., Type VW
R8	470K	½ watt	10% tol.	Allen Bradley, Type EB
R9	10K	1 watt	5% tol.	do Type GB
R10	2267	½ watt	½% tol.	Continental Carbon, Type UX½
R11	873	½ watt	½% tol.	do do
R12	100K	½ watt	½% tol.	do Type X½
R13	100K	½ watt	½% tol.	do do
R14	100K	½ watt	½% tol.	do do
R15	100K	½ watt	½% tol.	do do
R16	500K	½ watt	½% tol.	do do
R17	39K	1 watt	5% tol.	Allen Bradley, Type GB
R18	360	1 watt	5% tol.	do do
R19	510	½ watt	5% tol.	do Type EB
R20	1K	WW pot.	10% tol.	Int. Res. Co., Type VW
R21	10K	1 watt	5% tol.	Allen Bradley, Type GB
R22	470K	½ watt	10% tol.	do Type EB
R23	3.6K	1 watt	5% tol.	do Type GB
R24	2K	½ watt	5% tol.	do Type EB
R25	1K	WW pot.	10% tol.	Int. Res. Co., Type VW
R26	2.7K	1 watt	5% tol.	Allen Bradley, Type GB
R27	620	1 watt	5% tol.	do do
R28	620	1 watt	5% tol.	do do
R29	470K	½ watt	10% tol.	do Type EB
R30	39K	½ watt	5% tol.	do do
R31	18K	½ watt	5% tol.	do do
R32	200	½ watt	½% tol.	Continental Carbon, Type UX½
R33	200	½ watt	½% tol.	do do
R34	18K	½ watt	5% tol.	Allen Bradley, Type EB
R35	39K	½ watt	5% tol.	do do
R36	470K	½ watt	10% tol.	do do
R37	3.6K	1 watt	5% tol.	do Type GB
R38	1K	WW pot.	10% tol.	Int. Res. Co., Type VW
R39	2K	½ watt	5% tol.	Allen Bradley, Type EB
R40	10K	1 watt	5% tol.	do Type GB
R41	39K	1 watt	5% tol.	do Type GB
R42	1K	WW pot.	10% tol.	Int. Res. Co., Type VW
R43	510	½ watt	5% tol.	Allen Bradley, Type EB
R44	360	1 watt	5% tol.	do Type GB
R45	500 K	½ watt	½% tol.	Continental Carbon, Type X½
R46	100K	½ watt	½% tol.	do do
R47	8556	½ watt	½% tol.	do do
R48	100K	½ watt	½% tol.	do do
R49	100K	½ watt	½% tol.	do do
R50	2K	1 watt	5% tol.	Allen Bradley, Type GB
R51	1K	1 watt	5% tol.	do do
R52	680K	½ watt	10% tol.	do Type EB

CIRCUIT COMPONENTS MODEL 101 VAW METER DWG 101-150B 9-10-48

RESISTORS (cont.) (values in ohms)

R53	2K	1 watt	5% tol.	Allen Bradley, Type GB
R54	1K	1 watt	5% tol.	do do
R55	680K	½ watt	10% tol.	do Type EB
R56	1.8K	1 watt	5% tol.	do Type GB
R57	680K	½ watt	10% tol.	do Type EB
R58	1K	1 watt	5% tol.	do Type GB
R59	1K	WW pot.	10% tol.	Int. Res. Co., Type VW
R60	1K	1 watt	5% tol.	Allen Bradley, Type GB
R61	20K	1 watt	5% tol.	do do
R62	470K	½ watt	10% tol.	do Type EB
R63	18K	1 watt	5% tol.	do Type GB
R64	100K	1 watt	10% tol.	do do
R65	30K	1 watt	5% tol.	do do
R66	200	½ watt	5% tol.	do Type EB
R67	1K	WW pot.	10% tol.	Int. Res. Co., Type VW
R68	200	½ watt	5% tol.	Allen Bradley, Type EB
R69	680K	½ watt	10% tol.	do do
R70	15K	1 watt	10% tol.	do Type GB
R71	15K	1 watt	10% tol.	do do
R72	24	1 watt	5% tol.	do do
R73	15	1 watt	5% tol.	do do
R74	82K	1 watt	10% tol.	do do
R75	82K	1 watt	10% tol.	do do
R76	51	1 watt	5% tol.	do do
R77	51	1 watt	5% tol.	do do
R78	30K	1 watt	5% tol.	do do
R79	470K	½ watt	10% tol.	do Type EB
R80	510	½ watt	5% tol.	do do
R81	510	½ watt	5% tol.	do do
R82	10K	1 watt	5% tol.	do Type GB
R83	330K	1 watt	5% tol.	do do
R84	470K	½ watt	10% tol.	do Type EB
R85	270K	1 watt	5% tol.	do Type GB
R86	470K	½ watt	10% tol.	do Type EB
R87	2.7K	1 watt	5% tol.	do Type GB
R88	two 18K	1 watt	5% tol.	do do
R89	39K	1 watt	5% tol.	do do
R90	5K	WW pot.	10% tol.	Int. Res. Co., Type VW
R91	470K	½ watt	10% tol.	Allen Bradley, Type EB
R92	#900	½ watt		
R93	#5.4K	½ watt		
R94	#17K	½ watt		
R95	#17K	½ watt		
R96	150	10 watts	10% tol.	P.R. Mallory, Type 1HJ-150
R97	Compensator Resistor			

Components of other manufacture, equivalent to the above, may be substituted at our discretion.

Nominal values - Actual values as required to provide correct compensation.

CIRCUIT COMPONENTS MODEL 101 VAW METER DWG 101-150C 9-10-48

CAPACITORS

C1	.1 ufd	400V	Micamold, Type 345
C2	.1 ufd	400V	do do
C3	2 ufd	400V	Aerovox, Type 430
C4	2 ufd	400V	do do
C5	60 uufd	500V	Erie, Style L
C6	7-45 uufd	500V	do Style TS2A
C7	60 uufd	500V	do Style L
C8	7-45 uufd	500V	do Style TS2A
C9	7-45 uufd	500V	do do
C10	.1 ufd	400V	Micamold Type 345
C11	2 ufd	400V	Aerovox, Type 430
C12	.1 ufd	400V	Micamold, Type 345
C13	500 ufd	25V	Sprague, Type DFP
C14	500 ufd	25V	do do
C15	500 ufd	25V	do do
C16	.1 ufd	400V	Micamold Type 345
C17	2 ufd	400V	Aerovox, Type 430
C18	.1 ufd	400V	Micamold, Type 345
C19	7-45 uufd	500V	Erie, Style TS2A
C20	100-800 uufd	500V	
C21	7-45 uufd	500V	do Style TS2A
C22	60 uufd	500V	do Style L
C23	7-45 uufd	500V	do Style TS2A
C24	60 uufd	500V	do Style L
C25	1 ufd	400V	Aerovox, Type 430
C26	1 ufd	400V	do do
C27	.1 ufd	400V	Micamold, Type 345
C28	.1 ufd	400V	do do
C29	.1 ufd	400V	do do
C30	20/20 ufd	450V	Sprague, Type DFP
C31	.1 ufd	400V	Micamold, Type 345
C32	.1 ufd	400V	Micamold, Type 345
C33	50/50 ufd	150V	Sprague, Type DFP
C34	500 uufd	150V	do do
C35, C36	20/20 ufd	450V	do do
C37	1 ufd	400V	Aerovox, Type 430
C38	1 ufd	400V	Aerovox, Type 430
C39	1 ufd	400V	Aerovox, Type 430
C40	20/20 ufd	450V	Sprague, Type DFP
C41	7-45 uufd	500V	Erie, Style TS2A
C42	7-45 uufd	500V	Erie, Style TS2A
C43	50-500 uufd	500V	
C44	10 uufd	500V	Erie, Style K
C45	20 uufd	500V	Erie, Style K
C46	100 uufd	500V	Erie, Style L
C47	1000 uufd	500V	Aerovox, Type 1468
C48, C49	20/20 ufd	450V	Sprague, Type DFP
C50	.1 ufd	400V	Micamold, Type 345
C51	1000 uufd	500V	Aerovox, Type 1468
C52	200 uufd	500V	Erie, Style L
C53	7-45 uufd	500V	Erie, Style TSA

Components of other manufacture, equivalent to the above, may be substituted at our discretion.

COMPONENTS MODEL 101 VAW METER DWG 101-150D 9-10-48

TUBES

V1	6SF5	V6	6V6GT	V11	6AC7
V2	6J5	V7	6J5	V12	6SF5
V3	6SF5	V8	6SF5	V13	VR150
V4	6J5	V9	6J5	V14	6SL7GT
V5	6V6GT	V10	6SN7GT	V15	VR150
				V16	6AS7G
				V17	5V4G
				V18	22-4 Amperite
				V19	22-4 Amperite

MISCELLANEOUS

Rel	1N34	Germanium	Crystal	Diode
Re2	do	do	do	do

M Milliameter, special scale, Marion Elec. Inst. Co., Model 56I

S Wattmeter Element, John Fluke Engineering Co., Type I

T1 Power transformer, 117 volt primary with 105 volt tap, secondaries: 350-0-350, 5, 6.3, 6.3, 6.3 volts, 50-60 cps., 40°C max. temp. rise, special, A6530, Audio Development Co.

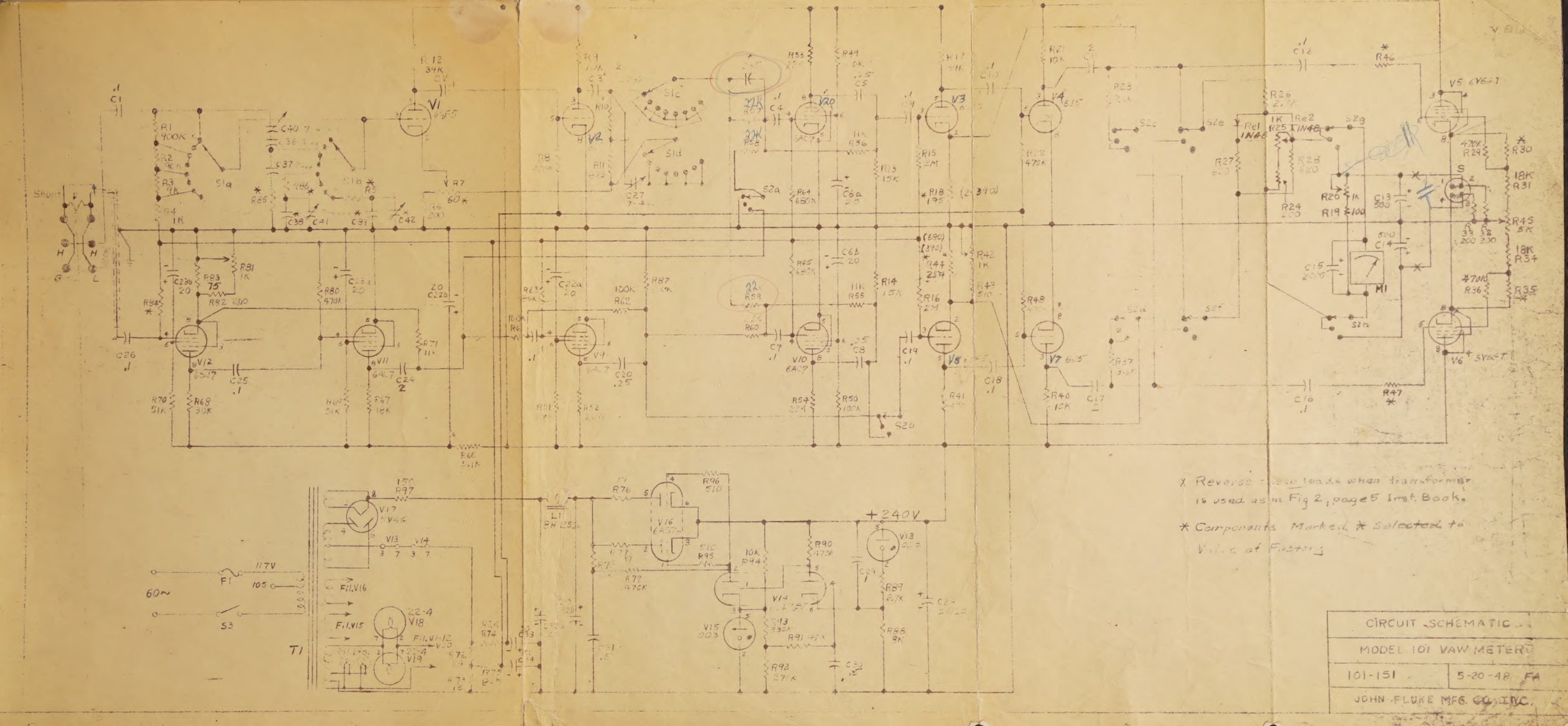
L1 Inductor, 8 henries, 125 ohms dc resistance.

F1 Fuse, 3 amperes, Littelfuse Type 3AG

S1 Switch, four circuit, 8 position assembly, special.

S2 Switch, three position, nine circuit assembly, special.

S3 Single pole, single throw toggle switch.


Shunt
H
G
L
S1a
S1b
S1c
S1d
S2a
S2b
S2c
S2d
S2e
S2f
S2g
S2h
V1 6SF5
V2 6SC7
V3 6SC7
V4 6SL7
V5 6Y6GT
V6 5Y4GT
V7 6U5
V8 6SN7
V9 6AU7
V10 6AU7
V11 6AU7
V12 6SN7
V13 V14
V15 OD3
V16 6AS7G
V17 5V4G
V18 OA2
V19 OA2
T1
F1 1/16A
117V
105
60~
S3
+240V
M1
1K
Rel 1N48
Rel 1N48
Reverse these leads when transformer is used as in Fig 2, page 5 Inst. Book.
* Components Marked * Selected to Value at Factory
CIRCUIT SCHEMATIC
MODEL 101 VAW METER
101-151
5-20-48 FA
JOHN FLUKE MFG. CO., INC.

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